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EP 0254333 A1

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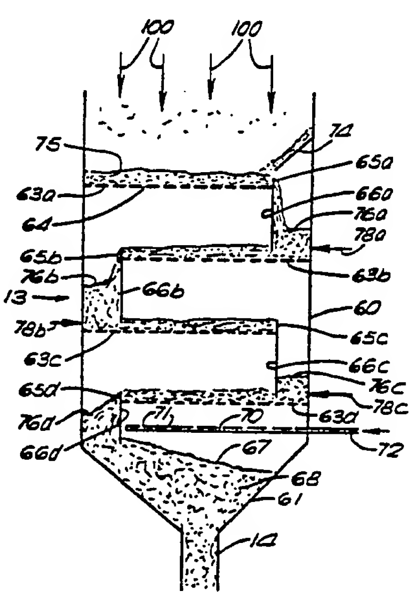
# (54) Catalyst stripper unit and process in catalytic cracking operations

(57) In an apparatus in which a hydrocarbon is catalytically cracked and the catalyst is stripped and regenerated, the stripper comprises a stripper vessel (60) containing stacked, vertically separated, perforated trays (63), each having an overflow weir (65) defining the maximum depth of a layer of catalyst particles thereon. Each weir (65) forms the top end of a respective downcomer tube (66) which delivers catalyst particles from one tray to the tray immediately beneath at a location which is diametrically opposite the weir (65) of that tray so that particles must pass across the tray before overflowing the weir and descending to the next lower tray. Steam (or another stripping medium) is passed (72) into the bottom of the stripper vessel (60) and rises via the perforations in the trays and via the layers of fluidized particles of catalyst maintained thereon by the weirs (65), thereby stripping hydrocarbon materials from the catalyst particles. The steam containing stripped hydrocarbon materials may be received above the stripper vessel in a separator forming part of the catalytic cracker reactor, and stripped catalyst particles are recovered from the base of the stripper vessel.

FIG. 2




At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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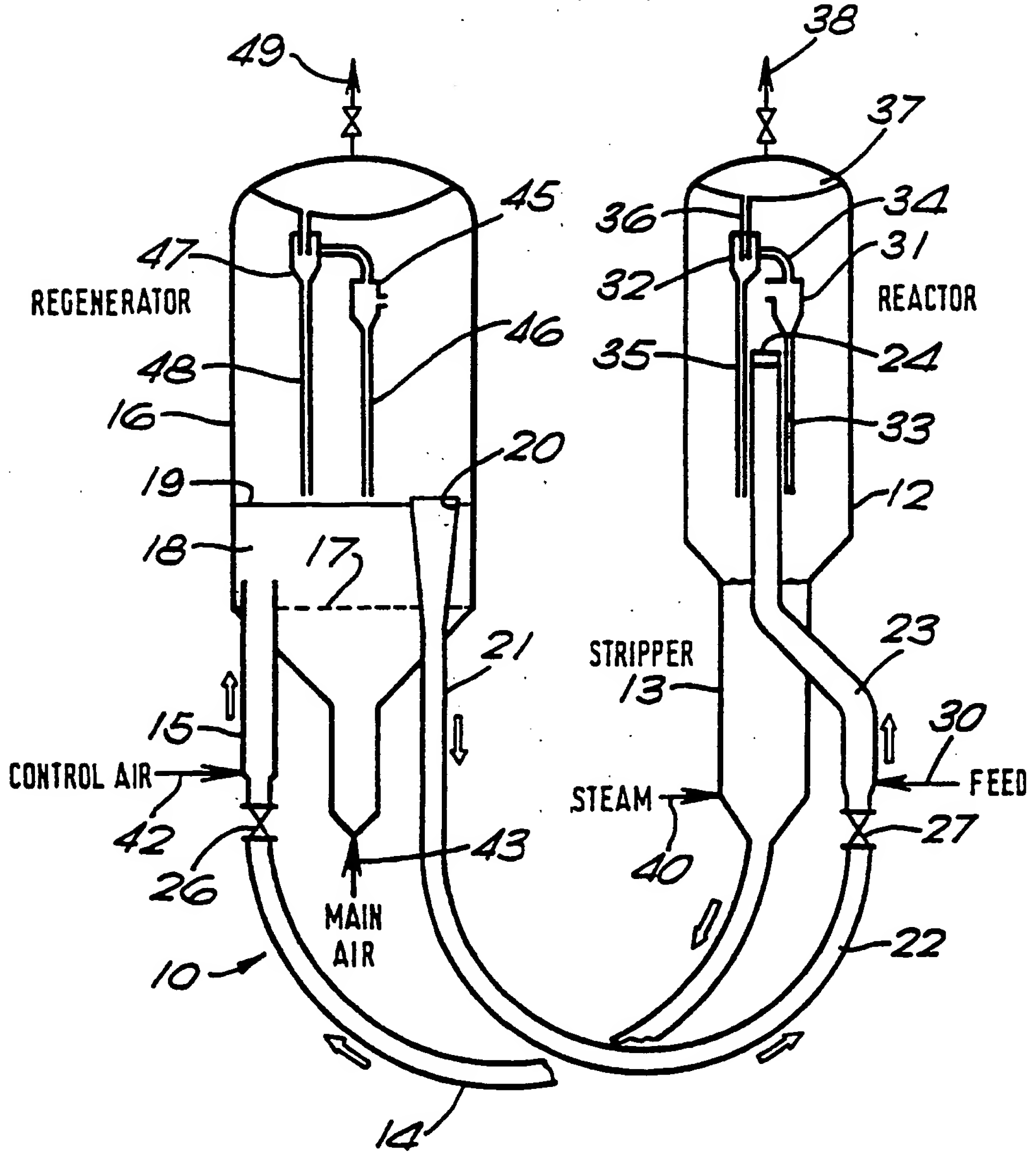
FIG. 1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REGENERATOR
REACTOR
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21
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STRIPPER
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CONTROL AIR
FEED
STEAM
42
43
27
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40
MAIN
AIR
22
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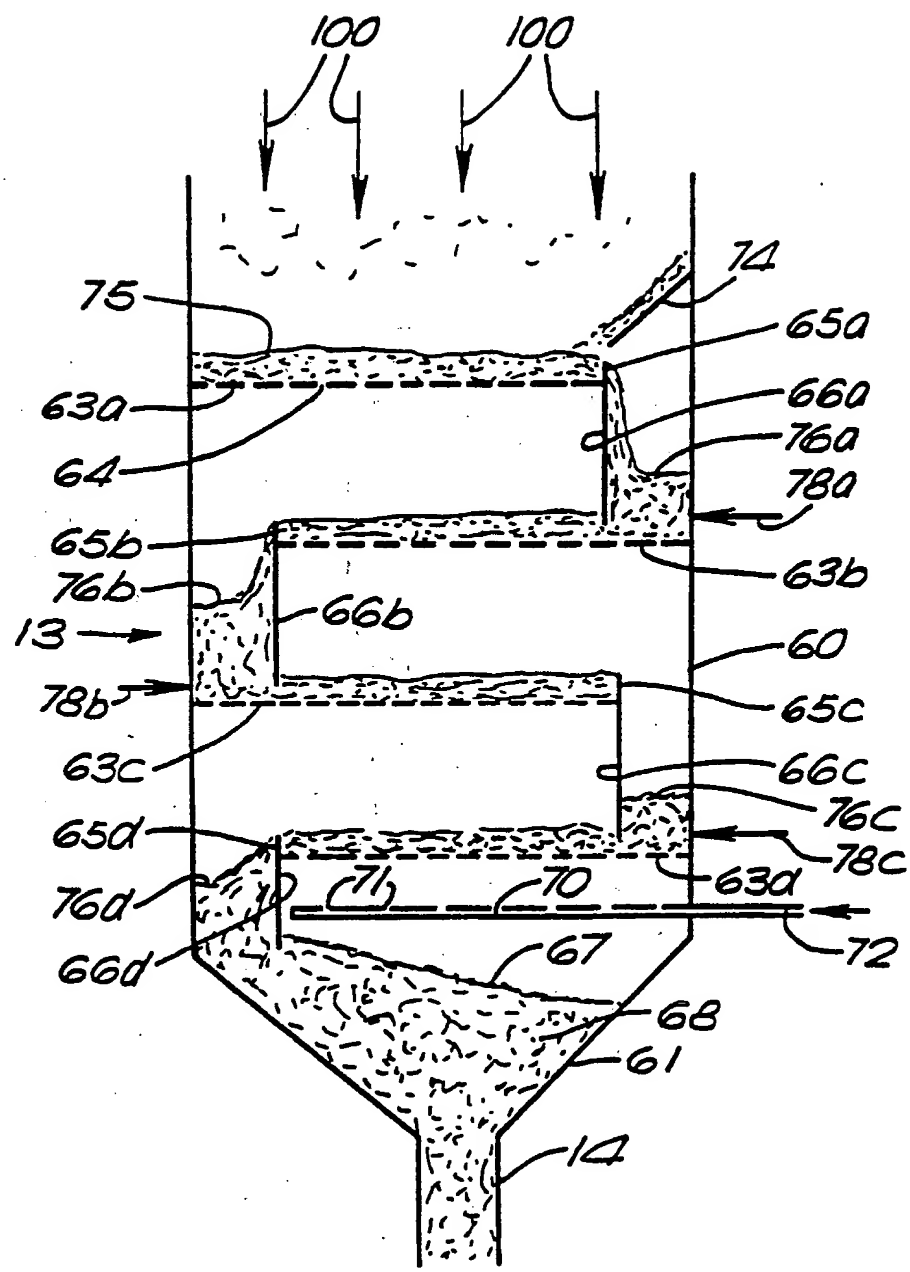
14

FIG. 2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# CATALYST STRIPPER UNIT & PROCESS IN CATALYTIC CRACKING OPERATIONS

The present invention relates to a catalyst stripper unit and process employed in catalytic cracking operations.

In catalytic cracking operations, a hydrocarbon feedstock is contacted with particles of cracking catalyst at hydrocarbon cracking conditions. The feedstock is converted to vapor-phase products which are recovered, and also to non-vapor phase products. The latter include carbonaceous materials which form a coke-like deposit on the catalyst particles, and also hydrocarbon materials which are adsorbed on and occluded in the catalyst particles. Since the said hydrocarbon materials are potentially valuable, it is conventional practice to attempt to recover them by contacting the catalyst particles with which they are associated with a stripping gas, usually high-temperature steam. Often, the contact with stripping gas is effected in a stripping zone, separated from the zone in which the cracking is effected, although it will be appreciated that the cracking and stripping can be effected in the same zone at different times. The contacting with stripping gas is usually performed in a counter-current manner, with catalyst passing downwardly and stripping gas passing upwardly, whereby stripped catalyst is recovered at the bottom region of the stripping zone and stripping gas containing stripped hydrocarbon materials is recovered at the top region of the stripping zone. In a common arrangement, the stripping zone contains an array of layers of rods extending across the stripping zone to prevent the descending catalyst particles from passing downwards in an uninterrupted vertical path, whereby better contacting (from the stripping point of view) between the particles and the stripping gas is obtained. Each rod may have a cross-section which is in the form of an inverted letter 'V' : such rods are known as "sheds".

Although known expedients for stripping hydrocarbons from catalyst with stripping gas are reasonably effective, stripped catalyst particles contain further quantities of potentially strippable hydrocarbon material. Since the next operation to which the catalyst particles is usually subjected is oxidative regeneration to remove the coke-like deposit therefrom, the

strippable hydrocarbons associated with the catalyst particles will be converted to coke and oxidized coke products during the regeneration operation and thereby lost. The amount of strippable material associated with the stripped catalyst particles not only detracts from the value of the cracked products, but also increases the amount of oxygen required for the regeneration step and increases the heat and gas output therefrom. In some catalytic cracking operations, the capacity of the air blower supplying air to the regenerator may be a factor limiting the throughput of feed and/or the conversion of the catalytic cracking unit. It will therefore be appreciated that any improvement in improving the efficiency of the stripping operation is likely to improve the economics of the catalytic cracking operation.

The present invention provides a catalytic cracking process wherein a hydrocarbon feed is contacted with cracking catalyst particles at cracking conditions, catalyst particles and vapors are separated, separated catalyst particles are stripped of adsorbed and/or occluded materials by contact with a stripping medium under stripping conditions, stripped catalyst particles are contacted with an oxidizing gas whereby carbonaceous deposits thereon are oxidatively removed and the catalyst particles are heated, and thus-heated catalyst particles are contacted with further amounts of hydrocarbon feed, wherein the stripping of the catalyst particles is effected by passing the particles across at least one substantially horizontal tray in a layer of fluidized particles while causing the stripping medium to pass through the tray from underneath so as to pass in contact with particles in the layer.

Preferably, fluidized particles from a layer on one tray pass to a layer on a subsequent tray spaced vertically therebeneath for a further stage of stripping by stripping medium. Preferably, stripping medium from the further stage of stripping on the said subsequent tray is employed to strip strippable material from the layer of particles on the said one tray.

Pr ferably, stripping medium containing stripped materials is recovered from above the highest tray and stripped catalyst particles are recovered from the layer of particles on the lowest tray.

Each tray may comprise an overflow weir defining the depth of the layer of fluidized particles thereon and a downcomer for receiving particles overflowing the weir and for directing said particles into the layer of a tray vertically spaced therebeneath.

Preferably, the particles have a predetermined mean residence time in the layer on the or each tray.

Preferably, the or each tray is formed with, or defines, perforations for the upward passage of stripping medium therethrough and into the layer of particles thereon. Each tray may be formed from perforated metal sheet with or without a bubble cap surmounting each perforation, or perforations each having upright tubular openings with or without valve members therein or comprises wire mesh or arrays of metal wires or bars or superimposed arrays of metal wires or bars.

The present invention also provides a catalytic cracking unit for converting hydrocarbons comprising a reactor zone in which regenerated or fresh catalyst particles are contacted with hydrocarbon feed at catalytic cracking conditions, a separation zone wherein catalyst particles from the reactor zone are separated from vapor-phase products, a stripping zone wherein catalyst particles from the separation zone are stripped of adsorbed and/or occluded strippable material by contact with a stripping medium under stripping conditions, a regenerator zone wherein catalyst particles from the stripping zone are contacted with an oxidizing gas to remove carbonaceous deposits and thereby to regenerate and heat the catalyst particles, and wherein heated, regenerated catalyst particles are contacted with further amounts of hydrocarbon feed in the reactor zone, wherein the stripping zone comprises at least one substantially horizontal tray having an overflow weir defining the depth of a layer of catalyst particles on the tray, a downcomer for receiving catalyst particles which spill over the overflow weir, and means permitting stripping medium below the tray to pass therethrough and in contact with catalyst particles in the said layer to strip and fluidize particles in the said layer.

The unit may comprise a plurality of similar or like substantially horizontal trays stacked one above the other with a space between vertically-adjacent trays, the downcomer of one tray being arranged to direct catalyst particles received therein into the layer of catalyst on the tray immediately therebelow, and the arrangement permitting stripping medium from the latter tray to pass upwardly through the said one tray into the layer of catalyst particles thereon.

Preferably, the weir of each tray and the bottom end of the downcomer from which the tray receives catalyst particles are so arranged that catalyst particles will spend a predetermined average residence time on the or each tray. The weir of the or each tray may be at one side of the tray and the bottom end of a downcomer from which catalyst particles are received from the tray above may be at an opposite side thereof. Preferably, the bottom end of the downcomer at one tray is below the level of the top of the overflow weir of that tray. The downcomer from one tray may be substantially vertically above the weir and downcomer of the next-but-one tray therebelow.

The or each tray may be formed from perforated metal sheet with or without a bubble cap surmounting each perforation, or with perforations each having upright tubular openings with or without valve members therein, or the or each tray may comprise wire mesh or arrays of metal wires or bars or superimposed wire meshes or arrays of metal wires or bars.

The unit preferably comprises means for passing stripping medium below the lowest tray of the stripping zone and means for receiving stripping medium and stripped strippable materials above the highest tray of the stripping zone. Preferably, the tray or trays and each respective weir and downcomer are received within a stripping vessel which receives unstripped catalyst particles at the top region thereof from the separator zone and stripping medium at the bottom region thereof.

The invention further provides a catalytic cracking process performed in the novel unit as described herein.

The invention also includes cracked products whenever made by the novel process described herein.

The invention will now be further described by way of non-limitative example only, and with reference to the accompanying diagrammatic drawings, in which:-

Figure 1 is a diagram (not to scale) of the principal features of a known fluidized catalytic cracking unit ("FCCU"); and

Figure 2 is a diagrammatic cross-section of a stripper embodying the invention; the stripper being shown to a larger scale than the FCCU of Figure 1, and only sufficient detail being illustrated for an understanding of its construction and mode of operation.

Reference is first made to the FCCU 10 of Figure 1 which comprises a reactor vessel 12 surmounting a stripper 13, the conical bottom of which communicates via a U-bend pipe 14 with a riser 15, the top of which is located within a regenerator vessel 16 at a level above the conical bottom thereof and slightly above a perforated grid 17 which extends across the top of the conical bottom. The regenerator 16 contains fluidized particles of cracking catalyst in a bed 18 which extends up to a top level 19 in the regenerator. Catalyst which tends to rise above level 19 overflows into the top region 20 of a downcomer 21 which is connected to one end of a U-bend pipe 22. The other end of the pipe 22 is connected to a riser 23 which extends substantially vertically and generally upwardly to a termination device 24 defining the top of the riser 23. Each U-bend pipe 14 and 22 has a respective closure valve 26, 27 for emergency and maintenance closing of the flow passages therethrough.

In broad terms, the operation of the FCCU 10 proceeds as follows: a hydrocarbon feed, usually consisting of, or containing, fractions boiling in the gas oil range and higher, is passed into a lower part of the riser 23 from a feed line 30. Usually, the feed from line 30 is introduced into the

riser 23 via a plurality of injectors (not shown) arranged equiangularly around riser 23. Hot regenerated catalyst particles passing upwardly through the riser 23 mix with, and heat, the injected feed in the riser 23 at the level of the feeds injectors and higher causing selective catalytic conversion of the feed to cracked products, which include vapor-phase cracked products, and carbonaceous and tarry cracked products which deposit on, and within the pores of, the catalyst particles. The mixture of catalyst particles and vapor-phase products enters the reactor vessel 12 from the riser 23 via apertures (not shown) in the side of the riser termination device 24, whereby to promote the separation of solids from vapors in the reactor vessel 12. Vapors together with entrained solids pass into a cyclone separation system which is herein shown to comprise two cyclones 31 and 32. The cyclone 31 provides primary separation of vapors and entrained solids, a major part of the latter being returned to the base of vessel 12 via a dipleg 33. The solids-depleted vapors from primary cyclone 31 are conducted via pipe 34 to the secondary cyclone 32 for further solids- separation, the separated solids being returned to the base of vessel 12 via dipleg 35, and cracked vapor products are recovered from cyclone 32 via conduit 36, plenum 37 and product line 38.

The catalyst particles from riser 23, together with separated solids from the cyclones 31 and 32, pass downwardly into the top of the stripper 13 wherein they are contacted by upwardly-rising steam injected from line 40 near the base thereof. The steam strips from the particles adsorbed and occluded strippable hydrocarbons, and these, together with the stripping steam, are recovered with the cracked products in product line 38.

Stripped catalytic particles bearing carbonaceous deposits circulate from the conical base of stripper 13 via the U-bend pipe 14 and the riser 15 into the bed 18 of catalyst particles contained in the regenerator vessel. The circulation of particles via the pipe 14 is promoted by control air which is passed into a lower region of the riser 15 from line 42.

The catalyst particles in the bed 18 are fluidized by air passed into the base of reactor vessel 16 from line 43. The air oxidatively remov s carbonaceous deposits from the particles and the heat of reaction (e.g., due

to combustion and part-combustion) raises the temperature of the particles in the bed to temperatures suitable for cracking the feed hydrocarbons. Hot regenerated catalyst overflows the top region 20 of the downcomer 21 and passes via the downcomer 21 into the U-bend pipe 22 for contact with further quantities of feed supplied from line 30.

The spent air passing upwardly from the top level 19 of the bed 18 in regenerator vessel 16 enters a primary cyclone 45 for separation of entrained particles, the latter being returned to the bed 18 via a dipleg 46. A further stage of solids separation is effected by secondary cyclone 47 which receives the solids-depleted gas from the primary cyclone 45, the separated solid being returned to the bed 18 via a dipleg 48. Spent air is recovered from the top of the regenerator vessel conduit 49.

Reference is now made to Figure 2 of the drawings which shows diagrammatically, and to a larger scale, the principal features of a novel stripper 13 which can be used with advantage in the FCCU shown in Figure 1.

The stripper 13 comprises a cylindrical vessel 60 having a conical bottom 61. Catalyst particles with which are associated adsorbed, occluded and deposited hydrocarbon materials, in addition to coke-like carbonaceous deposits, are received at the top end from reactor vessel 12 (as indicated by the arrows 100), and stripped catalyst particles leave the conical base 61 of the stripper via the top of U-bend pipe 14.

Within the cylindrical vessel 60, there are provided a plurality of vertically separated trays 63a, 63b, 63c, 63d. In practical embodiments, there may be more or less trays, the four trays illustrated being for the purpose of exemplification and explanation only. The trays 63 may each have any form which permits the establishment of a layer of catalyst particles thereon while permitting a stripping medium to pass through the tray and through the layer of catalyst particles thereon thereby to fluidize the particles. In the illustrated embodiment, the trays 63 are of the type known as sieve trays, each tray being formed from a plate perforated by holes 64.

At one end of each tray is an arcuate, cut-away hole, and an arcuate upstanding weir, respectively 65a, 65b, 65c, 65d, extends around the arcuate periphery of the respective hole and is welded (or otherwise attached) at its opposite ends to the interior of the cylindrical vessel 60. This manner of attachment is not shown but will be understood and appreciated by those skilled in the art.

Each weir 65 forms the upper end region of an arcuate sleeve of metal which extends below the respective tray 63 to define with the interior of the vessel 60 a respective downcomer 66a, 66b, 66c, 66d. The bottom end of each downcomer 66a, 66b, 66c is slightly lower than the top of the weirs 65b, 65c, 65d respectively. The bottom end of downcomer 66d is arranged to be at a level below the top level 67 of catalyst 68 which accumulates in the conical bottom 61 of the stripper, during operation of the cracking unit.

In the space between the top level 67 of catalyst 68 in the conical bottom and the lowest tray 63d is disposed a hollow ring distributor 70 having perforated walls (e.g. holes 71) to which is attached a feed line 72 for stripping media. In the present description, the stripping medium is steam, but it will be known and understood by those skilled in the art that other stripping media can be employed.

Stripping steam passed into the ring distributor 70 from the feed line 72 passes upwardly through the stripper 13, via the holes in the trays 63d, 63c, 63b and 63a. The unstripped catalyst from the reactor vessel 12 descends initially onto the top tray 63a, an inclined deflector plate 74 extending over the top downcomer 66a preventing catalyst from the reactor vessel 12 passing directly into the top downcomer 66a. The catalyst accumulates on the top tray 63a to a level 75 which is determined by the weir 65a. The layer of catalyst thus formed on the top tray 63a is subjected to the stripping action of steam passing through the holes in tray 63a, and the steam also maintains the catalyst particles on the tray in a fluidized state. The stripping steam together with stripped hydrocarbon material from the catalyst rises into the reactor vessel 12 and is recovered via product line 38.

As unstripped catalyst continues to descend from the reactor vessel 12 onto the top tray 63a, partly-stripped fluidized catalyst overflows the weir 65a and descends in the downcomer 66a where it accumulates to a level 76a and provides the catalyst which forms a layer on tray 63b, the depth of the layer being determined by the height of the weir 65b. Stripping steam passes through the holes in the tray 63b and strips catalyst thereon while maintaining the catalyst particles in a fluidized state, the resulting mixture of steam and hydrocarbon serving as the stripping medium for the layer of unstripped catalyst on the top tray 63a.

The excess of catalyst particles on tray 63b above the weir 65b overflows into the downcomer 66b where it accumulates to a level 76b, and is subsequently steam-stripped while in the catalyst layer on tray 63c. Catalyst enters the layer on tray 63c from the accumulation in the downcomer 66b at a rate which substantially equals the rate at which catalyst overflows the weir 65c and passes into the downcomer 66c, forming an accumulation therein up to a level 76c. The latter accumulation supplies catalyst to a catalyst layer on tray 63d up to a level dictated by the weir 65d, and catalyst in the layer on tray 63d is stripped by steam passing through the layer from the steam ring distributor 70 and the holes in tray 63d. The stripped catalyst overflowing the weir 65d in the downcomer 66d forms an accumulation therein up to a level 76d. The accumulations of catalyst in the downcomers substantially prevent stripping steam passing up the downcomers so that the catalyst is steam-stripped while on the trays 63. The height to which catalyst accumulates in each downcomer is a factor of the kinetics of operation of the stripper and those skilled in the art will know what dimensions to apply to the critical parts of the stripper to achieve desirable depths of catalyst accumulation in the downcomers and desirable residence times for the catalyst particles on each tray 65 and desirable steam-catalyst contacting rates on each tray 65. On each tray, the catalyst can approach equilibrium with respect to strippable hydrocarbon material removed therefrom and th stripper of the invention provides multiple count rcurrent equilibrium stages which are superior and more efficient from the points of view of steam utilization, steam-catalyst contacting and stripping than known strippers.

In order to maintain the accumulations of catalyst in each downcomer 66 in a flowable condition, relatively small amounts of "aeration" steam are passed into the lower region of each accumulation in the downcomers 66 from respective aeration steam lines 78a, 78b, 78c.

The invention is not limited to the precise embodiments described and/or illustrated. For example, in Figure 2, each downcomer/weir may be at the centre of an annular tray rather than at the side as shown. In such a construction, a deflector plate (preferably conical) will be disposed above each downcomer to prevent overflowing catalyst from one tray passing down more than one downcomer at a time.

CLAIMS:

1. A catalytic cracking process wherein a hydrocarbon feed is contacted with cracking catalyst particles at cracking conditions, catalyst particles and vapors are separated, separated catalyst particles are stripped of adsorbed and/or occluded materials by contact with a stripping medium under stripping conditions, stripped catalyst particles are contacted with an oxidizing gas whereby carbonaceous deposits thereon are oxidatively removed and the catalyst particles are heated, and thus-heated catalyst particles are contacted with further amounts of hydrocarbon feed, wherein the stripping of the catalyst particles is effected by passing the particles across at least one substantially horizontal tray in a layer of fluidized particles while causing the stripping medium to pass through the tray from underneath so as to pass in contact with particles in the layer.

2. A process as in claim 1 wherein fluidized particles from a layer on one tray pass to a layer on a subsequent tray spaced vertically therebeneath for a further stage of stripping by stripping medium.

3. A process as in claim 2 wherein stripping medium from the further stage of stripping on the said subsequent tray is employed to strip strippable material from the layer of particles on the said one tray.

4. A process as in any one of claims 1 to 3 in which stripping medium containing stripped materials is recovered from above the highest tray and stripped catalyst particles are recovered from the layer of particles on the lowest tray.

5. A process as in any one of claims 1 to 4 wherein each tray comprises an overflow weir defining the depth of the layer of fluidized particl s thereon and a downcomer for receiving particles overflowing the weir and for directing said particles into the layer of a tray vertically spaced therebeneath.

6. A process as in any one of claims 1 to 5 wherein the particles have a predetermined mean residence time in the layer on the or each tray.

7. A process as in any one of claims 1 to 6 wherein the or each tray is formed with, or defines, perforations for the upward passage of stripping medium therethrough and into the layer of particles thereon.

8. A process as in claim 7 in which the or each tray is formed from perforated metal sheet with or without a bubble cap surmounting each perforation, or with perforations each having upright tubular openings with or without valve members therein, or the or each tray comprises wire mesh or arrays of metal wires or bars or superimposed arrays of metal wires or bars.

9. A process according to any one of claims 1 to 8 substantially as described.

10. A catalytic cracking process substantially as described with reference to Figure 2 of the accompanying diagrammatic drawings.

11. A catalytic cracking unit for converting hydrocarbons comprising a reactor zone in which regenerated or fresh catalyst particles are contacted with hydrocarbon feed at catalytic cracking conditions, a separation zone wherein catalyst particles from the reactor zone are separated from vapor-phase products, a stripping zone wherein catalyst particles from the separation zone are stripped of adsorbed and/or occluded strippable material by contact with a stripping medium under stripping conditions, a regenerator zone wherein catalyst particles from the stripping zone are contacted with an oxidizing gas to remove carbonaceous deposits and thereby to regenerate and heat the catalyst particles, and wherein heated, regen rated catalyst particles are contacted with further amounts of hydrocarbon feed in the reactor zone, wherein the stripping zone comprises at least one substantially horizontal tray having an overflow weir defining the

depth of a layer of catalyst particles on the tray, a downcomer for receiving catalyst particles which spill over the overflow weir, and means permitting stripping medium below the tray to pass therethrough and in contact with catalyst particles in the said layer to strip and fluidize particles in the said layer.

12. A unit as in claim 11 comprising a plurality of similar or substantially like horizontal trays stacked one above the other with a space between vertically-adjacent trays, the downcomer of one tray being arranged to direct catalyst particles received therein into the layer of catalyst on the tray immediately therebelow, and the arrangement permitting stripping medium from the latter tray to pass upwardly through the said one tray onto the layer of catalyst particles thereon.

13. A unit as in claim 11 or claim 12 in which the weir of each tray and the bottom end of the downcomer from which the tray receives catalyst particles are so arranged that catalyst particles will spend a predetermined average residence time on the or each tray.

14. A unit as in claim 13 wherein the weir of the or each tray is at one side of the tray and the bottom end of a downcomer from which catalyst particles are received from the tray above is at an opposite side thereof.

15. A unit as in claim 14 in which the bottom end of the downcomer at one tray is below the level of the top of the overflow weir of that tray.

16. A unit as in any one of claims 11 to 15 wherein the downcomer from one tray is substantially vertically above the weir and downcomer of the next-but-one tray therebelow.

17. A unit as in any one of claims 11 to 16 wherein the or each tray is formed from perforated metal sheet with or without a bubble cap surmounting each perforation, or perforations each having upright tubular openings with or without valve members therein, or comprises wire mesh or arrays of metal wires or bars or superimposed wire meshes or arrays of metal wires or bars.

18. A unit as in any one of claims 11 to 17 comprising means for passing stripping medium below the lowest tray of the stripping zone and means for receiving stripping medium and stripped strippable materials above the highest tray of the stripping zone.

19. A unit as in any one of claims 11 to 18 wherein the tray or trays and each respective weir and downcomer are received within a stripping vessel which receives unstripped catalyst particles at the top region thereof from the separator zone and stripping medium at the bottom region thereof.

20. A unit as in any one of claims 11 to 19 substantially as described.

21. A catalytic cracking unit substantially as described with reference to Figure 2 of the accompanying diagrammatic drawings.

22. A catalytic cracking process performed in the unit of any one of claims 11 to 21.

23. Cracked products whenever made by the process of any one of claims 1 to 10 or claim 22.

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